Community Assistantship Program

Lewis Lake Environmental Assessment

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Prepared in partnership with Lewis Lake Property Owners Association

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CAP Report 084

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Executive Summary

I sampled Lewis Lake's water and aquatic vegetation, analyzed data from previous studies, and used this information to make recommendations for further action. I chose four sites in and around Lewis Lake: the inlet, the outlet, the bottom of the deep hole, and a site at the north end of the lake. Samples from these sites were analyzed for total phosphorus, nitrates, chlorophyll-a, alkalinity, dissolved oxygen, and temperature. Two sites, at the surface of the deep hole and in the southern basin, were sampled by Association members and analyzed for chlorophyll and phosphorus. Weekly Secchi disk readings were also taken at these sites.

The water sampling showed that phosphorus in Lewis Lake has increased slightly since 1997, but probably not enough to indicate a trend. The very northern portion of the lake, near the farm, had slightly higher phosphorus than the other in-lake sites, and the inlet to the lake had roughly ten times as much phosphorus as the lake itself. The outlet contained lower concentrations of phosphorus than the inlet. This indicates that the watershed is a source of phosphorus. Samples taken at the bottom of the deep hole indicated that the lake sediments are not a significant source of phosphorus.

The phosphorus, chlorophyll-a, and Secchi readings signify that Lewis Lake is borderline eutrophic, with an average trophic state index (TSI) of 52. This is at the upper end of TSI readings from previous years, which have ranged from 43 to 55, but it is lower than average for the North Central Hardwood Forest (NCHF) Ecoregion.

The most common aquatic plants were coontail (*Ceratophyllum demersum*), northern watermilfoil (*Myriophyllum sibiricum*), and white water lily (*Nymphaea odorata*). All three species are common in Minnesota. Coontail was especially

prominent, occurring at 89% of the sites sampled. It can grow at nuisance levels, but is also a beneficial plant, effective at removing phosphorus from the water column.

Curly-leaf pondweed (*Potamogeton crispus*), an exotic, invasive species, was also found in the lake. This species can grow in thick, extensive mats, out-compete native species, and cause algal blooms. It is especially successful in lakes with low water clarity (low Secchi readings) and high nutrient levels. In Lewis Lake, the population appeared to be sparse. If the water quality of Lewis Lake is maintained or improved, the curly-leaf pondweed may never reach nuisance levels.

Based on my findings, I recommend that the Lewis Lake residents undergo some shoreline restoration, continue their monitoring program, and educate area homeowners on lake-friendly activities. Shoreline restoration is the process of planting native plants in and around the shoreline. These plants remove phosphorus from the soil, aid water infiltration to the soil (where it can be filtered prior to entering the lake), provide habitat for wildlife, and slow erosive wave action. Since restorations can be difficult and expensive, I included a list of agency personnel who can provide advice, and a list of potential funding sources.

Shoreline restoration is an excellent way to improve lake water quality, but homeowners can do other, simpler things as well. Maintaining septic systems, avoiding phosphorus fertilizers, soaps, and detergents, and keeping yard waste out of the lake are important practices that maintain water quality. The Association could do some homeowner education, through mailings or reminders at meetings. In addition, the lake residents could be taught to identify curly-leaf pondweed, as part of an informal monitoring program.

The current monitoring program, which includes weekly Secchi disk readings and monthly water quality samples, provides a good record of lake water quality and can help local agency officials quickly notice if a problem exists in the lake. I recommend this program continue, and also recommend that a curly-leaf pondweed monitoring program begin.

Lewis Lake has decent water quality, but in order to maintain the plant community and prevent curly-leaf pondweed from becoming a nuisance in the lake, it would benefit from a reduction of phosphorus inputs. This can be accomplished through shoreline restoration and improved land use practices. In addition, a monitoring program will help determine quickly if problems arise and more drastic measures should be taken.

Background

Lewis Lake is a 258 acre lake located near Mora, Minnesota, in the North Central Hardwood Forest (NCHF) Ecoregion. Lewis Lake has a maximum depth of 40 feet, which occurs in the northern basin. The lake is largely spring-fed, but also receives inputs from a small inlet stream on the western portion of the lake and two ditches on the southern shore. It is considered a headwater lake because it has a permanent outlet, Stanchfield Brook (Klang et al. 1998). The inlet and outlet streams run most of the summer, but occasionally dry up during hot weather.

In 1997, the Minnesota Pollution Control Agency (MPCA), with the Minnesota Department of Natural Resources, the Kanabec County Soil and Water Conservation District (SWCD), and the Lewis Lake Association conducted an extensive survey of the lake as part of the Lake Assessment Program (LAP). Following this study, the Lewis

Lake Association, with the Kanabec County SWCD, began taking monthly water samples at two sites in the lake, which were analyzed for chlorophyll and phosphorus. In addition, lake resident Mary Shimshock participates in the MPCA's Citizen Lake Monitoring Program, and takes weekly Secchi readings at two sites in the lake.

The purpose of this study was to follow up on the LAP report by comparing data from the 1997 study with the monitoring data from following years, further investigating phosphorus inputs to the lake, performing an aquatic vegetation survey, and investigating specific ways to improve or maintain water quality in Lewis Lake.

Methods

Water chemistry

I obtained total phosphorus and chlorophyll data from 1997, 2000, 2001, 2002, 2004, and 2005 taken at a site in the southern basin and at the surface of the deep hole (Fig. 1). These data were collected by the MPCA and Association members and provided by the Lewis Lake Association and the Kanabec County SWCD. I also obtained total phosphorus and chlorophyll data from 1981, taken at an unspecified site. The data from 1997 included dissolved oxygen and temperature profiles, total kjeldahl nitrogen, total phosphorus, chlorophyll-a, nitrates, pH, and alkalinity. The data from some years included samples taken before and after lake turnover (in May, September, and October), but in others included only summer data. Since turnover can affect phosphorus and chlorophyll levels, I compared only the summer data (from June, July, and August). I plotted this data, looking for long-term trends and to compare this year's results.

I established four sample sites in and around Lewis Lake: the outlet (Stanchfield Brook), the western inlet, the bottom of the deep hole, and the north end (farm, Figure 1). The inlet and outlet were sampled in order to compare nutrient inputs and outputs. The deep hole was sampled at the bottom so that internal phosphorus loading could be estimated. The site at the north end of the lake served as an in-lake comparison to the other sites and was selected because of its proximity to a farm (a potential source of nutrient runoff).

Each site was sampled for total phosphorus, nitrates, alkalinity, and chlorophyll-a. Phosphorus is generally the limiting nutrient in aquatic systems, and can fuel algal blooms and excessive plant growth. In some aquatic systems, nitrogen can be the limiting nutrient and also fuel algal blooms and excessive plant growth. In addition, high levels of nitrate can be toxic. Chlorophyll-a is a pigment present in algae, and so measuring chlorophyll-a is another way to estimate algal biomass.

Each site was sampled 5 times during the summer. The outlet dried up in mid-August, so only 4 samples were achieved at that site. In addition to taking water samples, temperature, dissolved oxygen, specific conductivity, pH, and total dissolved solids were measured at each site. For the two in-lake sites, these variables were measured at one-meter intervals throughout the water column.

In addition, a site in the south basin and the surface of the deep hole were sampled monthly by Association members as part of their monitoring program. These samples were analyzed for total phosphorus and chlorophyll-a.

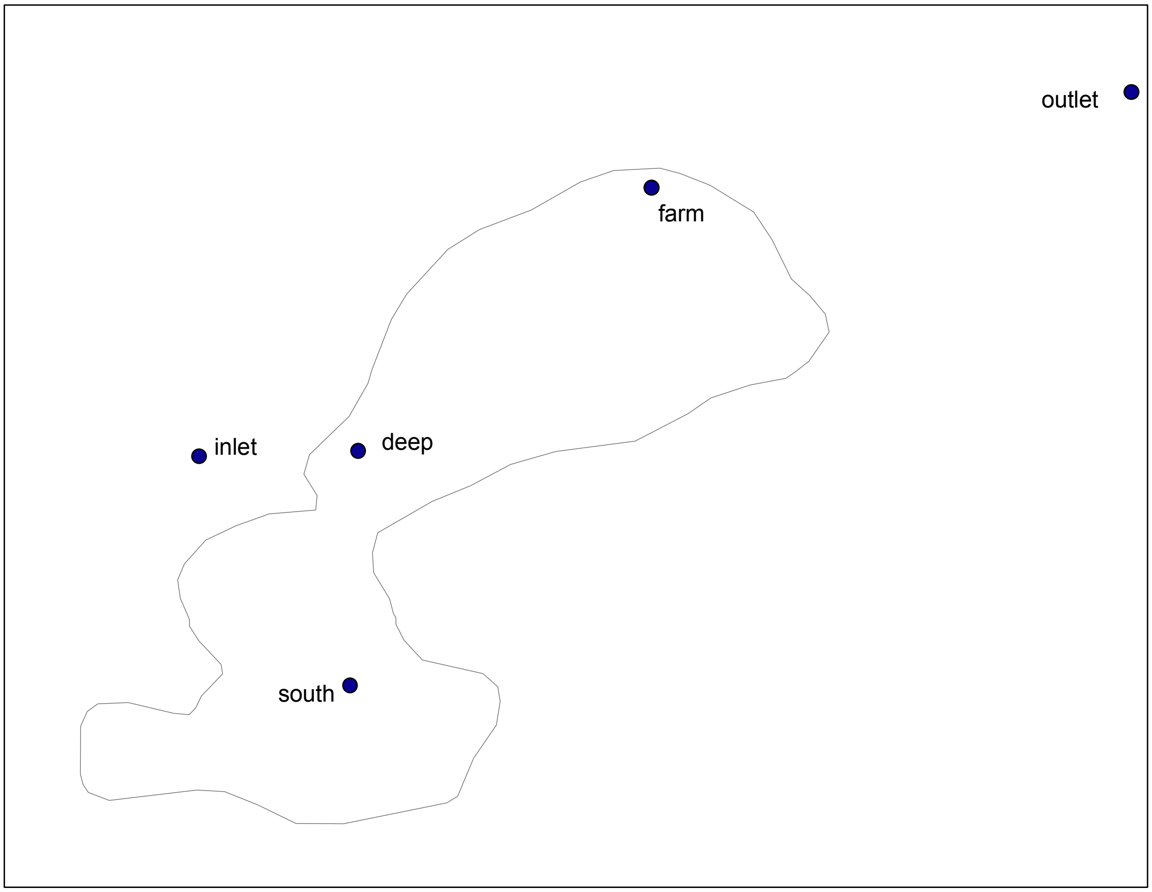

Figure 1. Water sampling sites on Lewis Lake.

After receiving the results of the chemical analyses, I plotted the data and compared it to previous years' values. I also calculated Carlson's trophic state index (TSI) for phosphorus, chlorophyll-a, and Secchi depth (Carlson 1977). TSI is an index designed to interpret trophic status (productivity) of a lake. It also allows phosphorus, chlorophyll-a, and Secchi depth to be compared on the same scale, and is calculated using the following equations:

Total phosphorus TSI (TSIP) = $14.42 \cdot \ln(TP) + 4.15$
Chlorophyll-a TSI (TSIC) = $9.91 \cdot \ln(Chl\text{-}a) + 30.6$
Secchi disk TSI (TSIS) = $60 - 14.41 \cdot \ln(SD)$

Plant Surveys

I conducted two plant surveys, one in mid-July and one in mid-August. In both surveys, I used the point-intercept method (Madsen, 1999). I set up a grid of sample points using ArcView, then transferred these points to a Garmin GPS (DeSanty et al. 2001). Using the GPS, I navigated to each sample point. If plants were present, I dropped a buoy to mark the spot, measured the Secchi depth and the water depth, and dropped a plant hook into the water. All the plants present on the plant hook, the buoy, or observed within one square meter of the buoy were recorded.

At a randomly chosen subset of sample points (approximately one-third of the sites), I also sampled plant abundance (Jessen and Lound, 1962). I threw the plant hook four times (one throw on each of the sides of the buoy), and recorded the plants present on each throw. Plant abundance was scored from 0-5: a plant received a score of zero if it was not present, a score of 1 if present on 1 throw; a score of 2 if present on 2 throws, and so on. A score of 5 was used if a plant was present on all four throws and filled up the tines of the plant hook.

In July, I collected plant data at 65 sites, and in August, I collected plant data at 99 points (Figure 2). This data was used to create a species list for Lewis Lake and to determine frequency and abundance of each species. In addition, I created vegetation maps of the most common species, using ArcGIS.

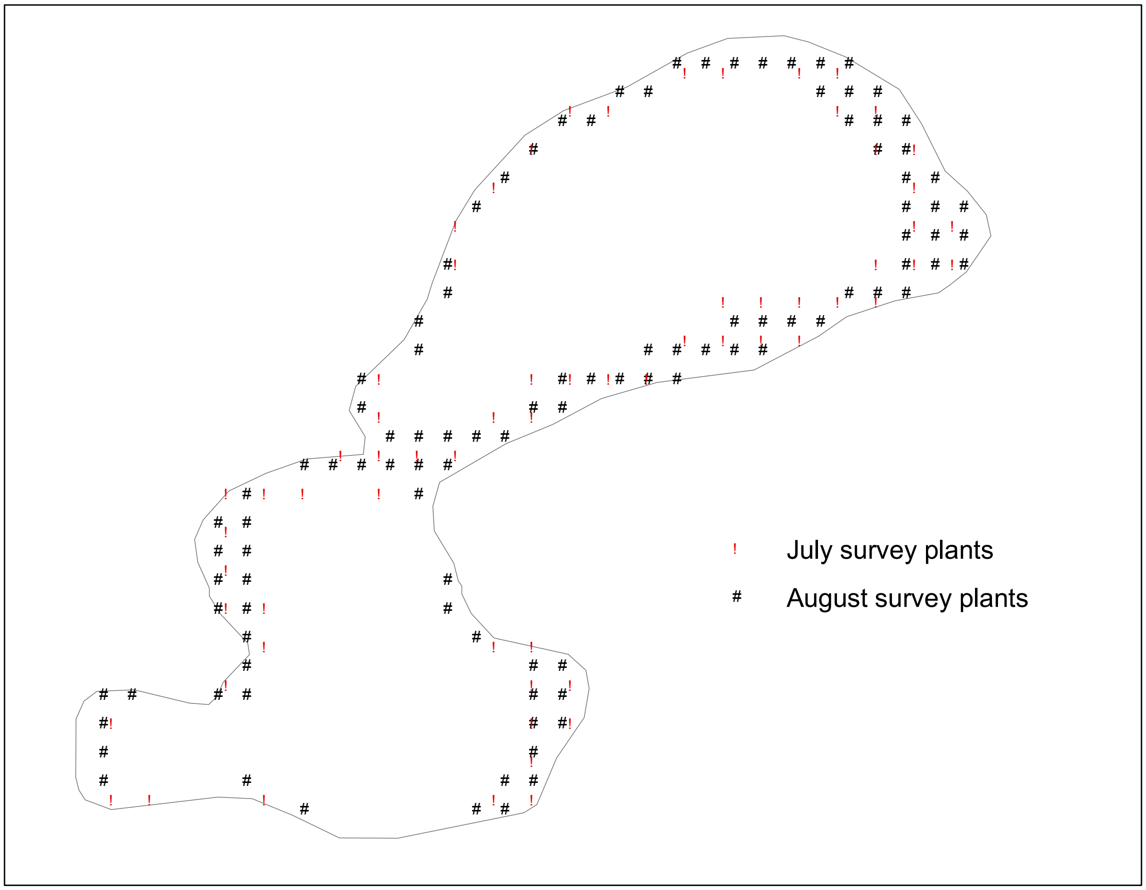

Figure 2. Sites sampled in the July survey (circles) and the August survey (triangles).

Results and Discussion

Water chemistry

Data from 1997, 2000, 2001, 2002, 2004, and 2005 were available for comparison at the site on the southern basin and the surface waters of the deep hole. Data from an unspecified lake site was available for 1981. During these years, average summer total phosphorus at the surface of the deep hole ranged from 0.021 mg/L in 2001 to 0.031 mg/L in 2002 and 2004 (Fig. 3). At the southern basin, it ranged from 0.021 mg/L in 2000 to 0.031 mg/L in 2001 and 2005. Chlorophyll-a values at the surface of the deep hole ranged from 3.3 µg/L in 2000 to 8 µg/L in 2001 and 2005. At the southern basin, they ranged from 3.7 µg/L in 2000 to 9 µg/L in 2002. This year's results were on the upper end of that range: total phosphorus averaged 0.027 mg/L at the deep site and 0.031 mg/L at the southern basin, and chlorophyll-a averaged 8 µg/L at the deep hole and 7 µg/L at the southern basin. At the farm site, total phosphorus averaged 0.043 mg/L and chlorophyll-a averaged 5.2 µg/L.

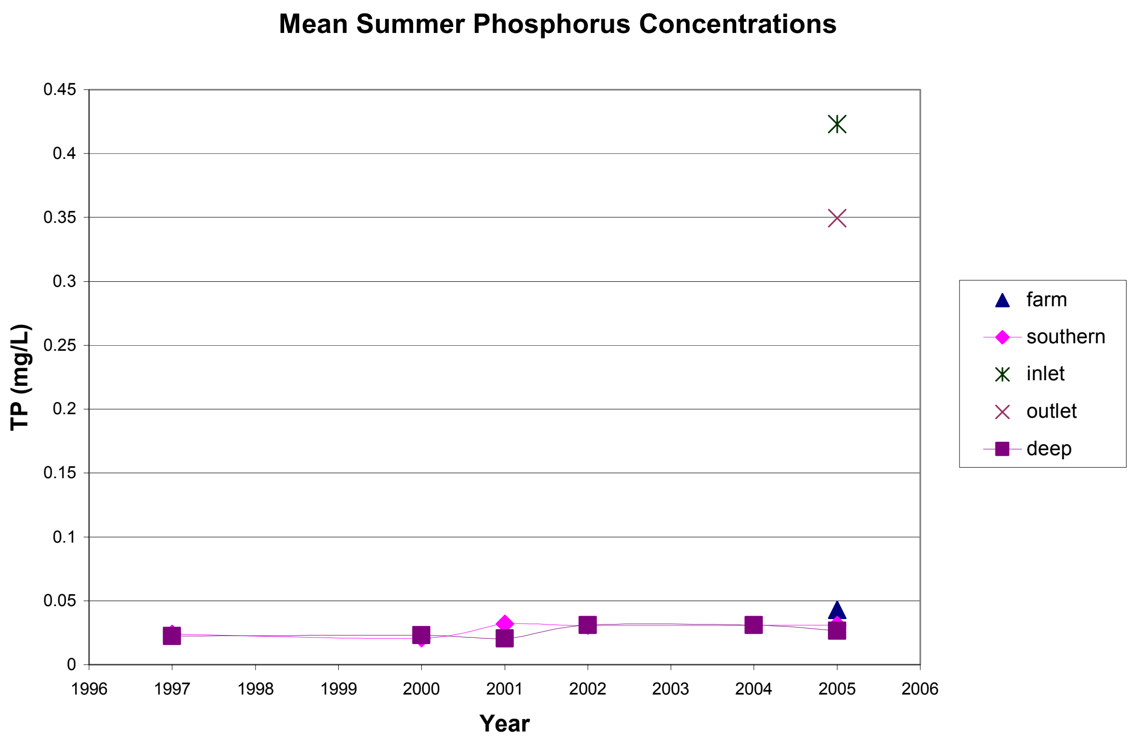

Figure 3. Summer phosphorus means, measure in milligrams per liter (mg/L).

The Minnesota Pollution Control Agency (MPCA) recommends that lakes in the North Central Hardwood Forests ecoregion maintain phosphorus levels of less than 0.04 mg/L to prevent nuisance algal blooms. For Lewis Lake, the MPCA recommends that phosphorus levels be kept at or below the 1997 summer average (0.023 mg/L, Klang et al. 1998). Although the current lake-wide average phosphorus levels are below 0.04 mg/L, the farm site averaged 0.043 mg/L, and the lake-wide average was higher than in 1997 level. The difference is only a few micrograms, and the levels are lower than in

1981 (0.047 mg/L), so this rise in phosphorus may be due to year-to-year variation. However, continued monitoring of these sites is important.

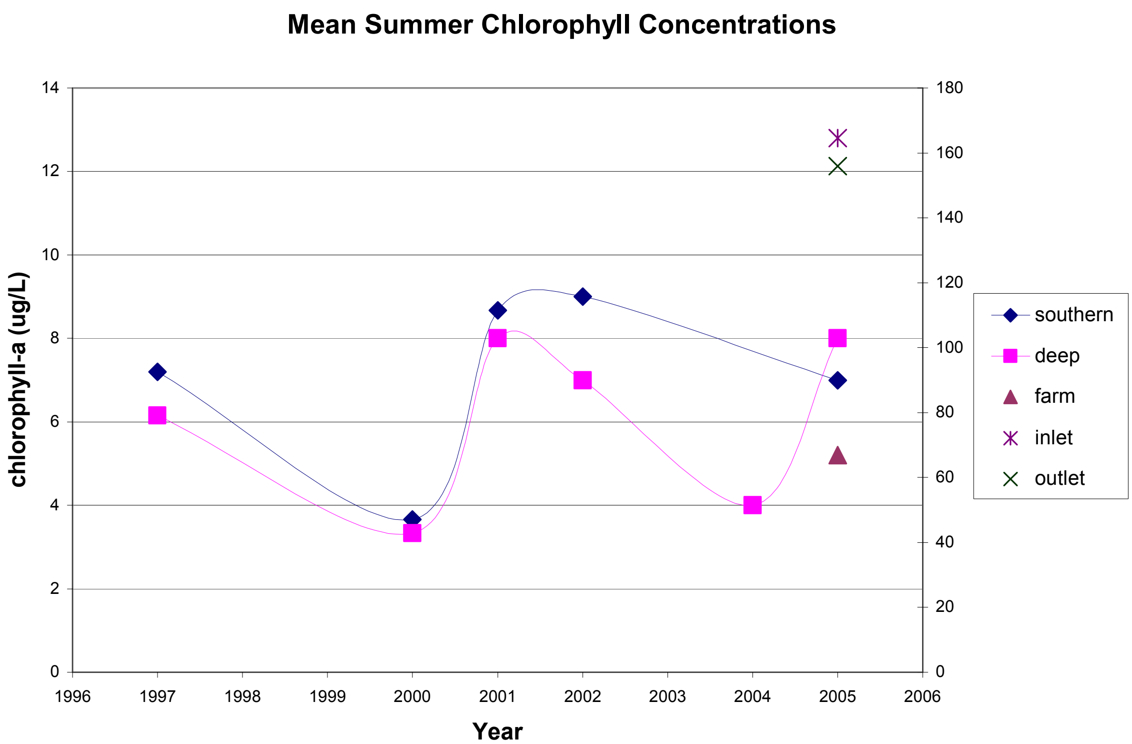

Figure 4. Summer chlorophyll means by site, measured in micrograms per liter (μg/L).

The lake inlet contained higher concentrations of phosphorus at all sample dates than the lake itself and higher concentrations than the outlet. The outlet runs through a corn field before reaching the sample spot, which is probably a source for some of the phosphorus. Since the outlet phosphorus levels are lower, even with the agricultural additions, this indicates that more phosphorus is entering the lake than leaving it.

The other inlets to Lewis Lake are springs, and groundwater generally has low levels of nutrients. The phosphorus entering the lake through the inlet will be partially diluted by the water entering through springs, but it is still important to note that phosphorus is entering the lake at concentrations ten times higher than what is currently present in the lake. Furthermore, watershed runoff not entering through the inlet contains additional phosphorus (due to contributions from agriculture, septic systems, and soil erosion).

The farm site had higher average summer phosphorus than the other two sites (0.043 mg/L), but lower chlorophyll (5.2 μg/L). The higher phosphorus may be due to runoff from the farm, and the lower chlorophyll may be due to the high levels of plant growth at the site – the water lilies block sunlight from reaching the water surface, thus preventing algal growth.

In addition to watershed runoff, phosphorus can be released from lake sediments. If the phosphorus levels at the bottom of the lake (hypolimnion) increase throughout the summer, this indicates that the sediments are releasing more phosphorus than is used by plants and other organisms in the lake, which is known as internal loading. Although Lewis Lake exhibited great variability in hypolimnetic phosphorus, there was not a steady increase (Fig. 5), indicating that the sediments were not a significant source of phosphorus loading to Lewis Lake. This is in contrast to 1997, when hypolimnetic phosphorus levels increased steadily throughout the summer, reaching a maximum of 693 mg/m^2.

More detailed sampling of the hypolimnion (e.g., taking samples at several different depths and analyzing sediment cores) could reveal more information about internal phosphorus release. If lake residents note problems with Lewis Lake in the future and decide to undergo another study, this might be an area to examine more closely.

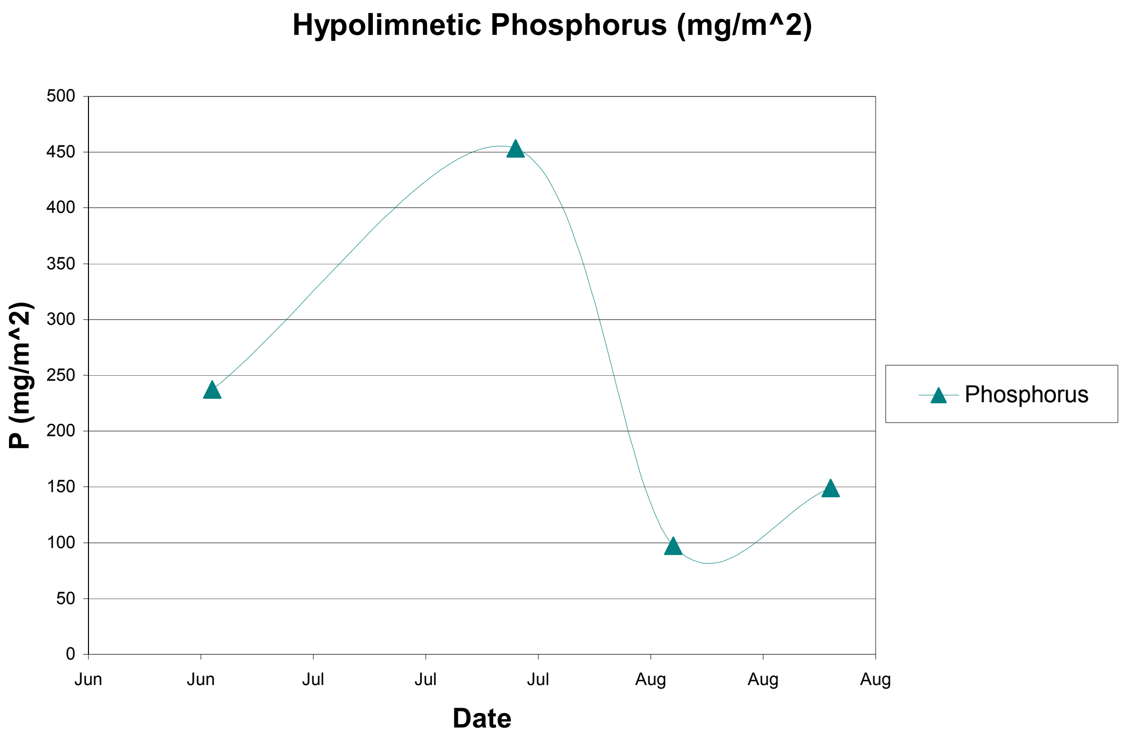

Figure 5. Change in phosphorus per square meter in the hypolimnion during the summer.

Trophic state index (TSI) in Lewis Lake has ranged from 43 to 54 since 1997 (Fig. 6). This year, TSIP (TSI calculated using phosphorus) averaged 54, TSIS (TSI calculated using Secchi depth) averaged 52, and TSIC (TSI calculated using chlorophyll) averaged 51. Mean TSI, calculated by averaging TSIP, TSIS, and TSIC, was 52. Lewis Lake is at the lower boundary of eutrophy, meaning that the hypolimnion (lake bottom) is likely to turn anoxic during the summer, and the potential for macrophyte problems and algal blooms exists.

This is the highest mean TSI Lewis Lake has had since 2002 (it also averaged 52 that year). Although this year's TSI readings were high for Lewis Lake, they are still lower than average for the NCHF Ecoregion, and are lower than the mean TSI in 1981, which was 53. Continued monitoring is important to determine if this gradual increase in TSI is part of a trend or if it simply reflects year to year variation.

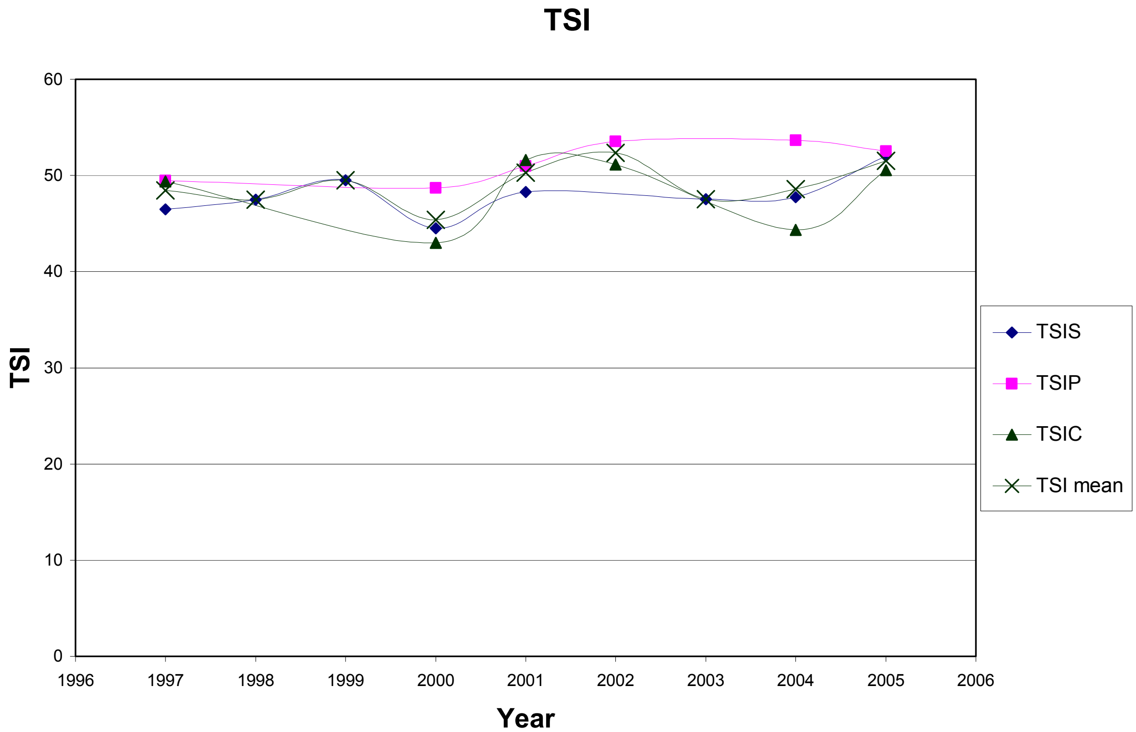

Figure 6. Trophic state index by year. TSI mean is the average of TSIP, TSIC, and TSIS.

Nitrate levels at the four sites ranged from <.01 mg/L to .21 mg/L and averaged .04 mg/L across all sites. These values are similar to data from 1997, in which nitrate averaged 0.05 mg/L. More nitrate was present in the inlets and outlets, but with two exceptions, they measured less than 0.03 mg/L. Lewis Lake does not have toxic levels of nitrate, usually defined as more than 10 mg/L (Rand et al. 1976).

Alkalinity, measured as mg/L of calcium carbonate, ranged from 103 mg/L to 150 mg/L in the lake, and ranged from 98 mg/L to 180 mg/L in the inlet and outlet. In 1997, alkalinity averaged 118 mg/L. The in-lake values are typical for the NCHF ecoregion (typically 75-150 mg/L), but the values for the inlet and outlet were quite variable. For both the inlet and outlet, values rose gradually through the summer, then dropped. This is possibly related to water level: the water level at both sites decreased until the last sample date, which immediately followed a large storm.

The lake was stratified by temperature throughout the summer, but was starting to mix on the last sampling date. It reached a maximum temperature of 26.9 °C (80.42° F) on July 11th (Fig. 7). Surface temperatures were higher this year than in 1997 (Klang et al. 1998).

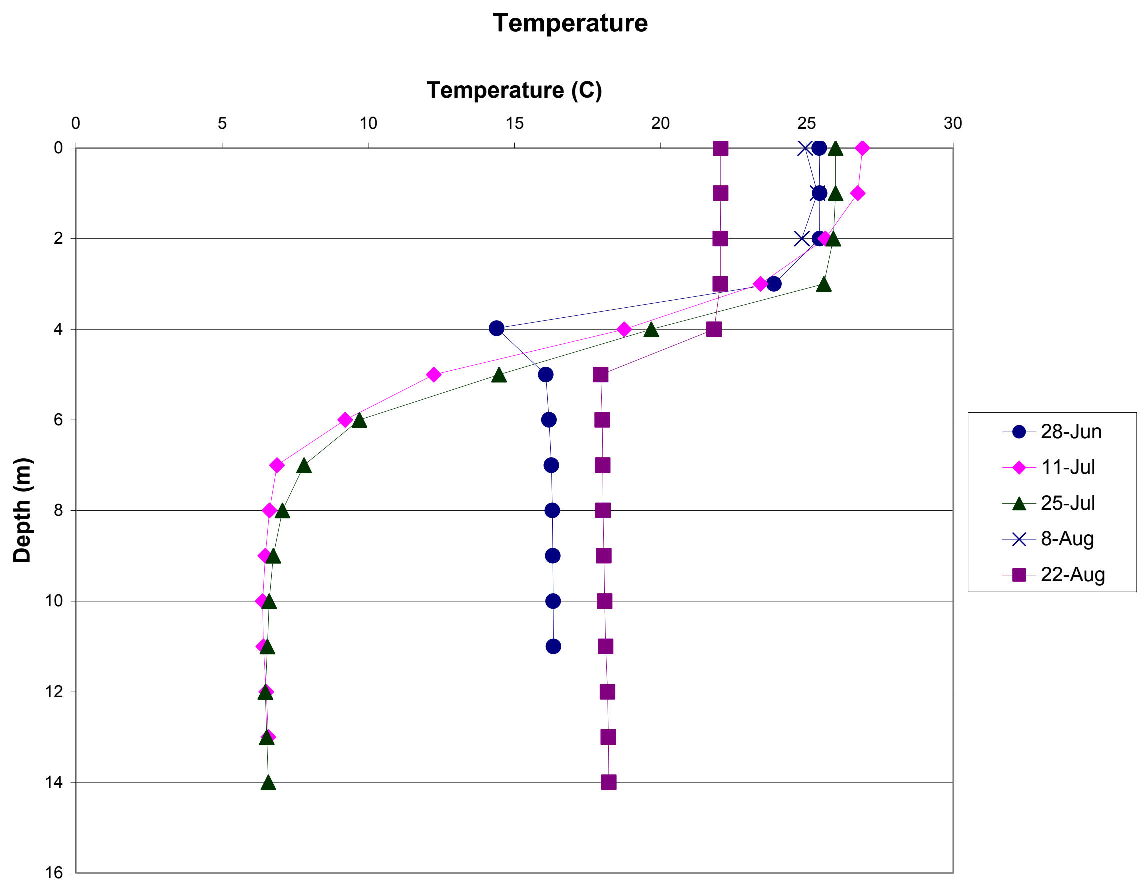

Fig. 7. Temperature profile of Lewis Lake.

Dissolved oxygen levels ranged from 4.8 mg/L to 9 mg/L in the epilimnion (surface) of the lake. The hypolimnion (bottom) of the deep hole had very low oxygen levels (anoxia), and ranged from 0.11 mg/L to 0.5 mg/L (Fig. 8). These hypolimnetic anoxic conditions are typical for mesotrophic and eutrophic lakes during the summer. In

1997, dissolved oxygen at the hypolimnion reached zero, but ranged from 7-10 mg/L in the epilimnion.

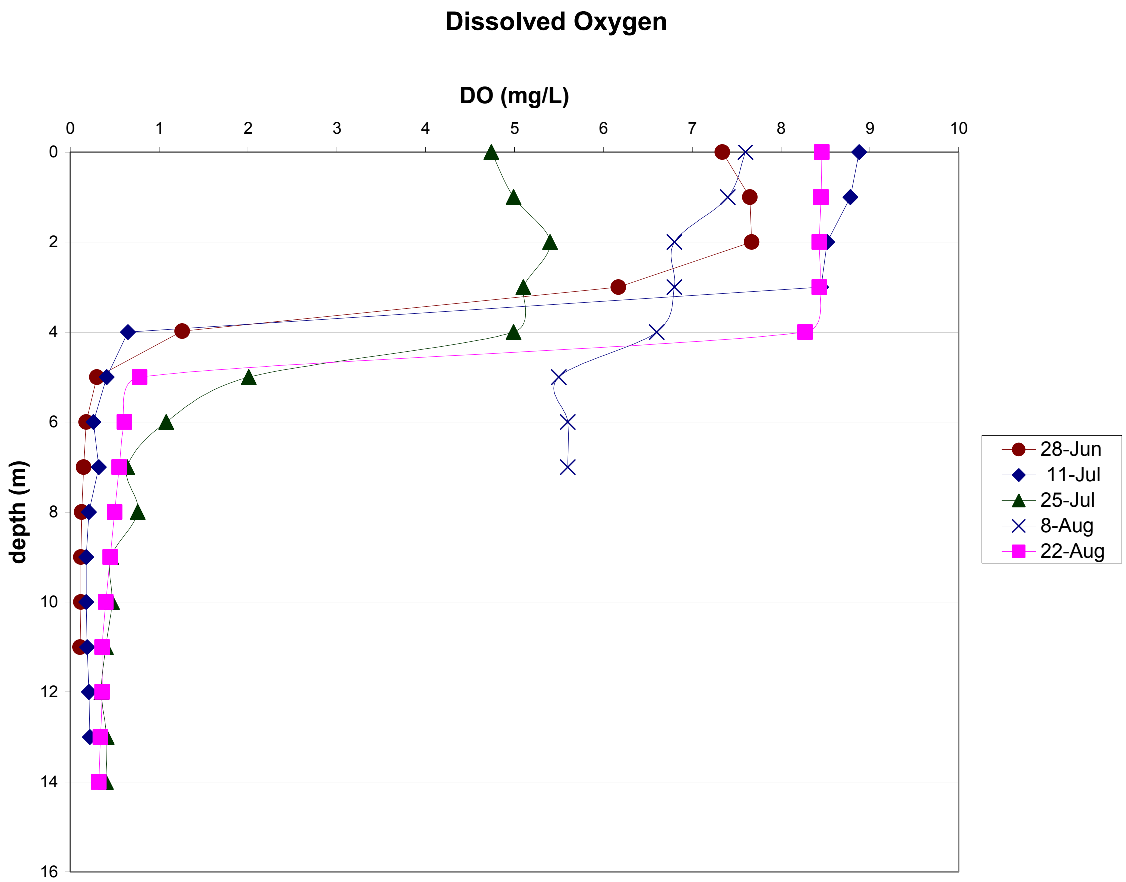

Figure 8. Dissolved oxygen profile of Lewis Lake.

Plant survey

The most frequently occurring plant in both surveys was coontail (*Ceratophyllum demersum*), occurring at 88% of the sites in July and 90% of the sites in August (Table 1). Northern watermilfoil (*Myriophyllum sibiricum*) was also common, occurring at 41% of sites in July and 45% in August. Other common plants in the lake include flat-stem pondweed (*Potamogeton zosteriformis*), forked duckweed (*Lemna trisulca*), muskgrass (*Chara*), and white water lily (*Nymphaea odorata*).

Coontail and white water lily were the most abundant plants, receiving an average score of 3.5 in July and 3.3 and 2.7, respectively, in August. Ribbon-leaf pondweed (*Potamogeton epihydrus*) received an average abundance score of 4; however, it was present at only 2 sites, indicating that it occurs infrequently in the lake, but is quite abundant at those sites.

Table 1. Plant species in Lewis Lake. Frequency (freq) is the percent of sites that contained the plant. Abundance (abund) is on a scale from 0-5, with 5 most abundant. "Present" indicates a plant was observed in the lake, but not at a specific sample point. "nd" stands for "not determined," and is used in cases where the plant abundance was not determined.

Common Name	Species	July freq	July abund	Aug freq	Aug abund
coontail	*Ceratophyllum demersum*	88	3.5	89	3.3
spiny hornwort	*Ceratophyllum echinatum*	13	1.4	3	1.5
muskgrass	*Chara spp.*	23	2.2	21	2.2
common waterweed	*Elodea canadensis*	2	1	1	1.5
forked duckweed	*Lemna trisulca*	20	2.3	25	2.4
northern watermilfoil	*Myriophyllum sibiricum*	41	2.5	45	2.7
slender naiad	*Najas flexilis*	20	1.8	17	2.2
stoneworts	*Nitella spp.*	5	1	11	2
small pond lily	*Nuphar microphylla*	3	2	1	1
spatterdock	*Nuphar variegata*	6	2	9	3
white water lily	*Nymphaea odorata*	17	3.5	22	2.7
large-leaf pondweed	*Potamogeton amplifolius*	2	2	6	1
curly-leaf pondweed	*Potamogeton crispus*	present	0	0	0
ribbon-leaf pondweed	*Potamogeton epihydrus*	2	2	2	4
long-leaf pondweed	*Potamogeton nodosus*	0	0	1	1
sago pondweed	*Potamogeton pectinatus*	0	0	2	1.3
clasping-leaf pondweed	*Potamogeton perfoliatus*	0	0	3	1
white stem pondweed	*Potamogeton praelongus*	8	1.5	1	nd
Richardson's pondweed	*Potamogeton richardsonii*	17	1.7	10	1.3
flat-stem pondweed	*Potamogeton zosteriformis*	32	2.1	37	1.9
stiff water crowfoot	*Ranunculus longirostris*	3	0	1	nd
white water crowfoot	*Ranunculus trichophyllus*	present	0	0	0
ditch-grass	*Ruppia maritima*	8	1	8	1
bulrush	*Scirpus spp.*	present	0	2	1
wild celery	*Vallisneria americana*	22	1.6	9	2.2
water stargrass	*Zosterella dubia*	9	2.7	12	1.2

Twenty-six total species were found in the lake during the two plant surveys. The number of species occurring at each site (species richness), ranged from 1 to 10 in July, and averaged 3.6. In August, species richness per site ranged from 1 to 9 and averaged

3. Twenty-three species were found in the lake in the July survey and 24 were found in the August survey.

Coontail is a common aquatic plant in Minnesota. It grows well in low-light conditions, which may partly explain its dominance of the Lewis Lake plant community: Lewis Lake is relatively deep, and many of the shallow areas are covered with lily pads, allowing little light to reach the water column. Coontail can grow at nuisance levels, but it can also be beneficial to a lake (Borman et al. 1997). Unlike most plants, it takes nutrients from the water column, rather than the sediment, and in doing so, it can reduce algal blooms, even at high phosphorus levels. (Mjelde and Faafeng 1997).

Northern watermilfoil is usually found in clear water lakes and is sensitive to high nutrient inputs. Its presence in the lake is indicative of good water quality (Borman et al. 1997).

The floristic quality index (FQI) is an estimate of the level of human disturbance in a lake (Nichols 1999). The FQI is based on the number of species present and the coefficient of conservatism (likelihood of the species to be present in a highly disturbed lake) of each species. In both July and August, the FQI was 31. This score is at the upper level for lakes in the hardwood forest ecosystem, indicating that despite the development and agriculture that has occurred in and around Lewis Lake, the plant community has remained relatively undisturbed. This index should be used with caution, however, because it was recently developed, and has not been specifically calibrated to Minnesota lakes.

Curly-leaf pondweed (*Potamogeton crispus*) was observed in the south basin of the lake, in the western-most bay. Curly-leaf pondweed generally disappears by the early part of July, so it did not appear in the plant survey, although some reproductive structures were observed. Curly-leaf pondweed is an exotic, invasive species. It begins its life cycle in the autumn, and grows slowly through the winter. Once the ice comes off the lake, it grows quickly, and in many cases it will form dense, monospecific mats of vegetation, shading out native plants, and making recreation difficult. Curly-leaf pondweed completes its life cycle at the end of June or early July. Plants form reproductive structures, called turions, then die (Catling and Dobson, 1985). The decomposition of the curly-leaf pondweed population returns nutrients to the lake, which can fuel a mid-summer algal bloom and even result in fish kills. Because curly-leaf pondweed is capable of growing under low-light conditions, it does very well in lakes with low water clarity (low Secchi depth).

The curly-leaf pondweed population in Lewis Lake did not appear to be at nuisance conditions. If the plant community remains diverse and the water clarity (Secchi depth) remains high, the curly-leaf pondweed may remain a small part of the plant community and not cause any problems (see Appendix for identification of curly-leaf pondweed).

Recommendations

Lewis Lake has decent water quality for its ecoregion and a healthy plant community. However, small nutrient increases and the accompanying decrease in water clarity could seriously impair Lewis Lake's water quality. Many of the plants in Lewis Lake are sensitive to nutrient levels and their demise would likely result in more frequent algal blooms. Furthermore, decreased water clarity would favor curly-leaf pondweed.

As a result, it is imperative that Lewis Lake maintain its water quality. This can be accomplished through existing and additional programs, including shoreline restoration, continued monitoring, and homeowner education.

Shoreline Restoration

Native plants remove nutrients from the water and soil, stabilize the sediment, provide habitat for wildlife, slow erosive wave action and runoff, and aid in water infiltration. By returning these plants to the shore, shoreline restoration can help maintain water quality. In addition, native plants require little to no maintenance once they are established, and many are adapted to dry conditions, eliminating the need for watering, mowing, and fertilizers. Shoreline restoration need not interfere with use of the lake. Homeowners can leave a path to the lake, maintain cleared areas around docks, and have a lawn in upland areas.

Restorations can be difficult and expensive, however. Personnel from the Department of Natural Resources and the University of Minnesota Extension Service, listed in the Appendix, can provide technical advice. In addition, both agencies offer publications, listed in the Appendix, and the Extension Service offers restoration workshops. Although none of these workshops are scheduled for the Mora area, custom workshops are available. Several funding opportunities are also available, both for individuals and groups.

Monitoring

The current monitoring program, including monthly water samples and weekly Secchi disk readings, provides excellent information. With this monitoring, changes in water quality can be detected quickly, and management changes made before the problem becomes critical. In addition, if noticeable changes occur, or if another, detailed study of the lake is required, the data from the current monitoring program can be used as a baseline.

Future efforts could include monitoring the curly-leaf pondweed population. It could be an informal monitoring program where residents learn to identify curly-leaf pondweed and watch for it, or it could be more formal, where interested residents sample set points on the lake, keeping track of the curly-leaf pondweed density (see Shoreland Plant ID for methods). If curly-leaf pondweed begins to spread beyond the western bay of the south basin, or if its density increases, the Association can develop and implement management strategies. The DNR can provide advice on this matter (contact information provided in the Appendix).

Homeowner Education

In addition to shoreline restoration and maintenance, individuals can do several things to uphold water quality: maintain septic systems, avoid phosphorus fertilizers, avoid soaps and detergents with phosphorus, remove as little aquatic vegetation as possible, and keep grass clippings and leaves out of the lake. These steps could be communicated to all homeowners, possibly through periodic mailings or reminders at association meetings.

Acknowledgements

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Appendix 1: Funding Sources

Note: this list is current as of July 2005. Funding programs may change names, requirements, or be eliminated, while others may be added. Continue to check with state and federal agencies and non-profit organizations for additional funding opportunities.

Shoreland Habitat Restoration Grants Program

Administered through Minnesota Department of Natural Resources
Provides 75% of total project funds via reimbursement
Applications are due September 16, 2005
Main focus of projects should be revegetating the shoreline
Funding available to private citizens, organizations, and local units of government
Contact Neil Vanderbosch, 651-772-7965, neil.vanderbosch@dnr.state.mn.us or John Hiebert, 651-296-2548, john.hiebert@dnr.state.mn.us
http://www.dnr.state.mn.us/grants/habitat/shoreland.html

Minnesota State Cost-share Program

Administered through Kanabec County Soil and Water Conservation District
Cost-share up to 75%
Eligible projects include filter strips, shoreland protection, and others
Low-interest revolving loans also available for septic system improvements
Continuous applications
Contact Kelly Osterdyk at Kanabec County SWCD (320-679-4160)
http://www.bwsr.state.mn.us/grantscostshare/costshare/factsheet2.html

Partners for Fish and Wildlife Program

Provides 50% cost-share to projects that provide habitat for fish and wildlife
Contact Lori Woff (Lori_Woff@fws.gov) – state coordinator or Greg Brown (Greg_Brown@fws.gov) – regional coordinator
http://www.fws.gov/partners

Environmental and Conservation Partnerships Grant Program

Administered by the Minnesota DNR
Grants for habitat enhancement, research/survey projects, environmental service

Must have matching funds, maximum award is $20,000
Applications were due March 2005 – check later for 2006 grants
Contact Grants Manager, 651-296-6047
http://www.dnr.state.mn.us/grants/habitat/env_cons_part.html

Minnesota Office of Environmental Assistance

Several grants available
Contact Grants Coordinator, 651-296-3417 or 800-657-3843
FY2005 programs closed, check website for 2006 grants
http://www.moea.state.mn.us/grants/current.cfm

Clean Vessel Act Grant

75% cost-share, up to $10,000
Development or improvement of sanitation facilities for boaters to improve/maintain water quality
Applications accepted year-round
More info/to apply: kentskaar@dnr.state.mn.us, 651-297-2798
http://www.dnr.state.mn.us/grants/recreation/clean_vessel.html

Minnesota ReLeaf Program

Purchasing and planting of native trees for energy conservation, wildlife, etc
50% cost-share, up to $10,000
Contact Ken Holman, 651-296-9110, ken.holman@dnr.state.mn.us or Cambridge Area Forestry Office, 763-689-7101
http://www.dnr.state.mn.us/grants/forestmgmt/releaf.html

Sustainable Woodlands Program

Tree planting, land stabilization, development of a forest stewardship plan
65% cost-share, maximum of $10,000/year
Contact Area DNR Forester, 763-689-7101 or Private Forest Coordinator, 651-296-5970
http://www.dnr.state.mn.us/grants/forestmgmt/lcmr.html

Forest Stewardship Program

Individual landowners with 20+ acres of forest
Purpose is to develop a forest stewardship plan for that land, with the assistance of the DNR, SWCD, or other organization
Deadline is past (5/3/05) – check on program in future
Contact Private Forest Program Coordinator, 651-297-4467 or Cambridge Area Forestry Office, 763-689-7101
http://www.dnr.state.mn.us/grants/forestmgmt/stewardship.html

Project CORE (Cooperative Opportunities for Resource Enhancement)

fisheries projects that improve angler access and fish habitat
Contact Mike Halverson, (651) 296-0789, mike.halverson@dnr.state.mn.us
http://www.dnr.state.mn.us/grants/habitat/core.html

Wildlife Habitat Incentives Program (WHIP)

Individual landowners with 5+ acres
Emphasizes management and establishment of declining species' habitats
Part of 2002 Farm Bill, but non-farmers are eligible
Cost-share 75%, up to $10,000
Contact local NRCS Office, 320-679-2080
http://www.nrcs.usda.gov/programs/whip/

Landowner Incentive Program (LIP)

Administered by U.S. Fish and Wildlife Service
Assists landowners who wish to protect listed species
Must be in LIP focus area and must have listed species on or near property
http://www.fws.gov/midwest/FederalAid/programs/lip.htm

The McKnight Foundation

Awards money to non-profit organizations and government agencies
Educational programs, conserving land, improving water quality
Ongoing deadlines for application
Focused on the Mississippi River – not sure about Lewis Lake's eligibility
Contact Gretchen Bonfert at 612-333-4220
http://www.mcknight.org/grantsprograms/howtoapply.aspx

Non-Point Source Water Pollution Control

Administered by the state, funded by the U.S. Environmental Protection Agency
Usually fund heavily degraded systems – probably not applicable to Lewis Lake
Contact Kevin Pierard, pierard.kevin@epa.gov
http://www.pca.state.mn.us/water/cwp-319.html

Clean Water State Revolving Fund

Revolving low-interest loans to communities for wastewater treatment
Lewis Lake septic system upgrades – may or may not be eligible
Contact Andrew Lausted, Lausted.Andrew@epa.gov
http://www.pca.state.mn.us/water/revolvingfund.html

Appendix 2: Agency Contacts

Mary Blickenderfer
Extension Educator
U of M Extension Regional Center
1861 E. US Hwy 169
Grand Rapids, MN 55744
218/327-4616 (phone)
218/327-5966 (fax)

blick002@umn.edu
Shoreline restoration and workshops

Wendy Crowell
NR Specialist Ecosystem Services
Natural Resources Dept
500 Lafayette Rd
Box 25
St Paul, MN 551554025
Wendy.Crowell@state.mn.us
651/282-2508 (phone)
651/296-1811(fax)
Curly-leaf pondweed advice and information

Dean G. Paron
NR Spec Int Fisheries
Natural Resources Dept
DNR Hinckley Office
306 Power Ave N Box 398
Hinckley, MN 55037
Dean.Paron@state.mn.us
320/384-7721
Experience with shoreland resorations

Tim Pharis
Private Lands Specialist
NR Spec Int Wildlife
Natural Resources Dept
DNR Cambridge Office
800 Oak Savanna Lane SW
Cambridge, MN 55008
Tim.Pharis@state.mn.us
763/689-7110
No cost for technical assistance
Provide expert advice, referrals, and sources of cost-share

Kelly Osterdyk
District Manager
Kanabec Soil and Water Conservation District
2008 Mahogany St, Ste. 3
Mora, MN 55051
kelly.osterdyk@mn.nacdnet.net
320-679-3781
Funding, shoreline restoration, other watershed questions

Lonnie J Thomas
NR Area Hydrologist
Natural Resources Dept
DNR Brainerd Headquarters
1601 Minnesota Dr
Brainerd, MN 56401
Lonnie.Thomas@state.mn.us
218/833-8689
Shorline restoration information

Emily Wolf
Regional Extension Educator
Water Resource Management & Policy
University of Minnesota Extension Service
Fergus Falls Regional Center
223 West Cavour Avenue
Fergus Falls, MN 56537-2103
(218) 998-5790
wolfx222@umn.edu
Shoreline restoration information and workshops

Appendix 3: Resources for Shoreline Restoration

Borman, S., Korth, R., Temte, J. 1997. Through the looking glass: A field guide to aquatic plants. Wisconsin Lakes Partnership: Stevens Point, WI.

Henderson, C., Dindorf, C., Rozumalski, F. 1999. Lakescaping for wildlife and water quality. Minnesota's Bookstore: St. Paul, MN.

-------. 1999. Restore your shore. CD-ROM. Minnesota's Bookstore: St. Paul, MN

Tekiela, S. 1999. Wildflowers of Minnesota: Field Guide. Adventure Publications: Cambridge, MN.

Appendix 4: Water Quality Data

Table 2. Water quality data by site in Lewis Lake.

Date	Site	alkal (mg/L)	TP (mg/L)	nitrates (mg/L)	chlor-a (ug/L)	pheo (ug/L)
6/28/05	deep	140	0.078	0.01	11	25
7/11/05	deep	108	0.038	0.01	5	1
7/25/05	deep	150	0.149	0.01	13	16
8/8/05	deep	114	0.032	0.01	3	1
8/22/05	deep	114	0.049	0.02	6	1
6/28/05	farm	122	0.055	0.01	4	1
7/11/05	farm	112	0.03	0.01	4	1
7/25/05	farm	112	0.023	0.01	5	1
8/8/05	farm	106	0.076	0.01	6	3
8/22/05	farm	103	0.031	0.01	7	1
6/28/05	inlet	146	0.403	0.02	26	15
7/11/05	inlet	148	0.283	0.12	10	5
7/25/05	inlet	166	0.499	0.1	20	2
8/8/05	inlet	180	0.474	0.01	1	1
8/17/05	inlet	84	0.457	0.21	7	4
6/28/05	outlet	150	0.24	0.03	102	84
7/11/05	outlet	152	0.3	0.01	200	122
7/25/05	outlet	164	0.785	0.1	320	33
8/8/05	outlet	.	.	.	.	.
8/17/05	outlet	98	0.073	0.02	2	1

alkal = alkalinity. TP = total phosphorus. chlor-a = chlorophyll-a. pheo = pheophytin.

Table 3. Temperature by depth at the deep hole in Lewis Lake.

Temperature (C)

Depth (m)	June 28	July 11	July 25	Aug 8	Aug 22
0	25.42	26.9	25.98	24.94	22.05
1	25.44	26.74	25.98	25.36	22.05
2	25.43	25.63	25.9	24.83	22.04
3	23.87	23.41	25.58		22.04
4	14.39	18.75	19.68		21.83
5	16.07	12.24	14.47		17.95
6	16.18	9.21	9.7		18
7	16.26	6.88	7.8		18.02
8	16.3	6.62	7.06		18.03
9	16.31	6.48	6.75		18.06
10	16.32	6.39	6.61		18.08
11	16.33	6.41	6.55		18.12
12		6.51	6.48		18.18
13		6.58	6.53		18.21
14			6.58		18.23

Table 4. Dissolved oxygen by depth at the deep hole in Lewis Lake

Dissolved Oxygen (mg/L)

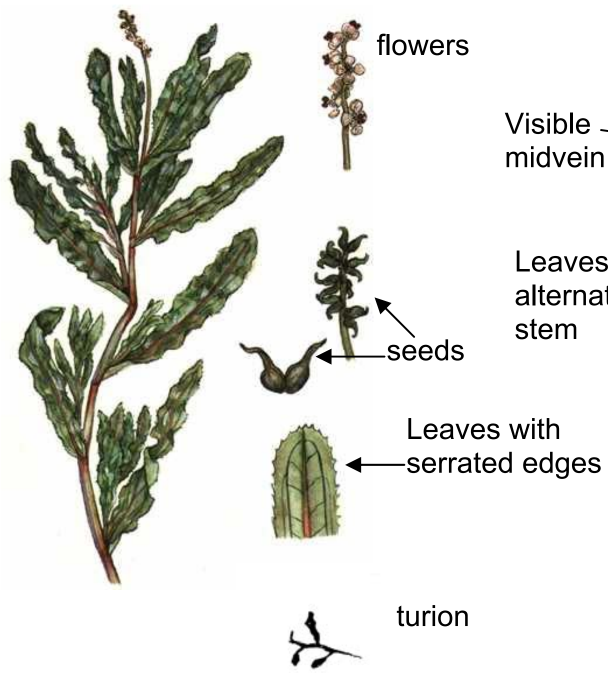
Depth (m)	June 28	July 11	July 25	Aug 8	Aug 22
0	7.34	8.88	4.74	7.6	8.46
1	7.65	8.78	4.99	7.4	8.45
2	7.67	8.52	5.4	6.8	8.43
3	6.17	8.45	5.1	6.8	8.43
4	1.26	0.65	4.99	6.6	8.27
5	0.3	0.41	2.01	5.5	0.78
6	0.18	0.26	1.08	5.6	0.61
7	0.15	0.32	0.64	5.6	0.55
8	0.13	0.21	0.76		0.5
9	0.12	0.18	0.46		0.45
10	0.12	0.18	0.47		0.4
11	0.11	0.19	0.4		0.36
12		0.21	0.35		0.36
13		0.22	0.41		0.34
14			0.4		0.32

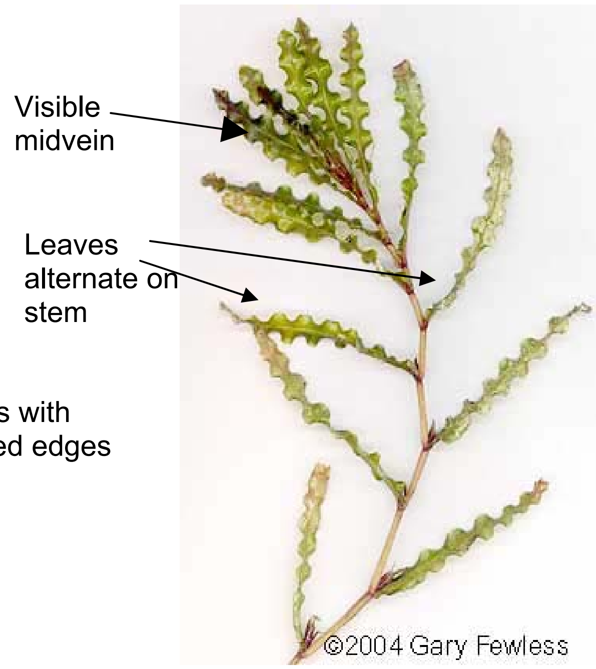
Table 5. Secchi depth in meters at two sites in Lewis Lake.

Date	Deep	South
6/4/2005	1.52	1.22
6/18/2005	1.52	1.22
6/25/2005	1.83	1.52
7/4/2005	2.13	1.83
7/10/2005	2.13	1.83
7/17/2005	1.83	1.83
7/31/2005	2.13	1.83
8/5/2005	2.13	1.83
8/21/2005	1.83	1.52
9/4/2005	1.83	1.52

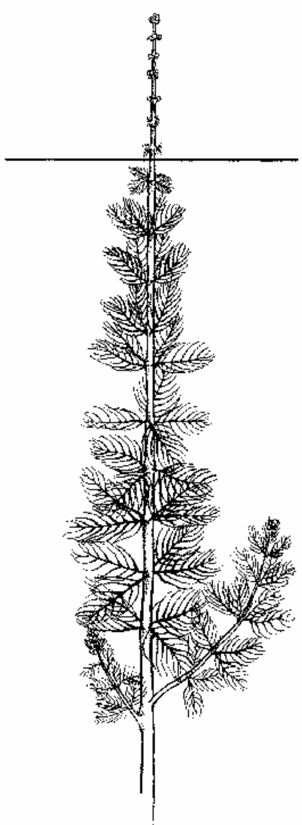
Appendix 5: Identification of Lewis Lake aquatic plants

Curly-leaf pondweed





Northern watermilfoil



Coontail